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THE JOURNAL OF PHILOSOPHY

PSYCHOLOGY AND SCIENTIFIC METHODS

A DEFINITION OF CAUSATION. I

THE category of causation was once regarded as rather fundamental in metaphysics; but in western civilization man's interest in man has so taken possession of the field that philosophers now study almost exclusively the problems of subjectivism, human knowledge, or the nature of consciousness. Consequently it is difficult to find a modern discussion of causation which attempts anything like an exhaustive investigation of its meaning. It is treated in passing, with a remnant of respect for an old tradition, and generally from the basis of an already finished system. Some have even gone so far as to say there is no such thing as a cause.¹ This extreme statement—though made, at one time or another, of most of the important categories—hardly merits much attention; for when the scientist or the ordinary man uses the word cause, he is assuredly thinking of something. The only question is what? Indeed the question, whether this or any other concept has objectivity, is subsidiary to the question, what does the concept mean? Only after decision of the latter can the former be answered. Meanwhile, we should not make too much of the fact that current interest is not centered upon defining objective categories. Fashions of thought change; the old discarded view is restored—witness the present revival of Platonic realism—and sooner or later we may expect a renewal of interest in things that are not man's. And of these causation appears to be one of the principal ones. The plain fact that in our transactions with reality—so far as reality is vouchsafed to mortals—the category is inevitable and ubiquitous, at least suggests this. We may reflect, too, that the great bulk of the increase of our knowledge of reality in detail, *i. e.*, the content of the sciences, has come from looking for the causes of things. *Prima facie* it would hardly seem possible to form a philosophical system, either closed or open, without first according this category a serious treatment.

¹ So Mach: "There is no cause and effect in nature; nature has but an individual existence; nature simply *is*." *Science of Mechanics* (Eng. transl.), page 483. Cf. also B. Russell, *Proc. Arist. Soc.*, 1912-13, page 1.

The main reason of its importance lies in the fact that it deals with the connection of events. Philosophers seek to know the universe as a whole—be it of externally joined parts or an articulated system. The thread which connects these parts in time is causation. From one isolated event it leads to another. Can one understand the constitution of the world unless he knows how this is done, of what stuff this glue is made that attaches one event to another? Other modes of connection there may be, too; but any mode that unites, that gives a rational, systematic character to the world, is of fundamental significance for philosophy.

The problem of causation, being so central, is a very large one; the bibliography alone is appalling. This same term has meant many different things in the course of history; it has been believed to represent a substance, a force, an event, a relation, a mere word. Presumably no broad treatment of it to-day could dispense with these labors of the past. They are manifold and full of ingenious speculation, and some of the best work, within the last century, is little known. The standard histories (König's, Lang's, Göring's, etc.) give but small idea of this last. It is, however, manifestly undesirable to bring much of this material into a discussion in a journal. What we shall have to say will be along a line which has not been touched as yet, except in a very fragmentary way. It is not regarded by the writer as final, but simply as a piece of work that needs to be done, and has not been done. It is also regarded by the writer as the natural way, and, philosophically, the indispensable way of attacking this problem—for reasons which shall soon be given. But it will remain subject to certain philosophical criticisms which can not be answered by any result obtained in this investigation, but must be examined on their own account. For that part of the problem the contributions of past thought form a necessary basis. We pass now to the statement of our particular topic and method.

When physics tells us that heat causes a body to expand, that the electric current causes a magnetic needle to be deflected, or that a ray of light is due to the motion of electrons, what is the character of the connection between the members in each pair? Suppose we take the analysis science furnishes of each cause, and of each effect, and of the process by which the one turns into the other; suppose this accomplished for all kinds of cases which are treated in the various sciences; and suppose, finally, that we find, common to all the cases, a certain logical structure. Then that structure will constitute an empirically grounded definition of causation. A definition obtained by this method will presumably be the only one which applies to real events and is valid in the actual world; for the causation men know and profit by is one which reveals itself always in specific cases, and

it is not likely that its character can be understood quite apart from its behavior in those cases. Nevertheless, this method has seldom been pursued, and never, I think, with a sincere attempt at comprehensive treatment. The usual method is rather to treat the category as a member of a hierarchy of concepts, as part of a rational ideal, whose meaning can be deduced by analysis of that ideal and is quite independent of empirical characters. Whether in the expansion of a body by heat, or in the explosion of gunpowder by a spark, the causal connection is assumed to be indifferent to the particular nature of the event; as indifferent as is number to the color of the objects numbered. Such a procedure is to the one first described as abstract to concrete. It is not confined to either idealism or realism; it is used by Russell and G. E. Moore as well as Natorp and Royce. The only difference is that the former pair would consider the concept independent of the mind; the latter, due to the mind's activity. And it may very well be true that there is a certain ideal concept, fitly called causation, which is definable by abstract deductive methods. Yet it remains doubtful, until it is compared with an empirical definition, whether this is the causation the scientist uses and the philosopher evaluates in his criticism of science. And if it is not that kind of causation, it is, though certainly of some value, yet of much less value than the latter. Philosophy is interested primarily in the real, and the world with which the sciences deal is at least fairly high in the scale of realities. So the kind of causation, by virtue of which one body hitting another moves it, is for philosophy considerably more important than any abstractly perfect ideal which does not hold of actual events. Naturally one can not deny beforehand that the definitions given by the abstract method really do apply to the existent world. The method itself, however, does not seem likely to give the kind of result which philosophy desires to get; some "schematism" at least would be necessary, to show that such a concept would be applicable to the concrete. In seeking a definition of causation, accordingly, we must choose the empirical or concrete method.

The position here taken is independent of the general issue about the "externality" or "internality" of relations. Those who hold the former view do indeed tend to believe that, in general, concepts are independent of, and external to, their particular examples in the actual world; while advocates of "internality" do not admit such independence. While we do here claim that the concept causation can not be understood, in so far as *philosophy* desires to understand it, when treated as thus independent, it is not because of a general adoption of the doctrine of internality. It is because the causation which alone is deserving of serious study seems to be the causation

which is "internal" to the actual world, which forms the object-matter of the sciences. Causation is, as Kant showed, a category *prima facie* concerned with actuality; number and quantity are not by definition so directly concerned with it. Its own special nature, then, makes causation internal to the particulars of the actual world.

Our purpose is then to determine the meaning of causation as it is found to hold in the actual course of events; that is, in the details of the sciences. It is not, at present, to decide any question about the metaphysical rank of the category. This inquiry is only a necessary preliminary to such a decision; it would get the concept fairly before us, and ignore philosophical criticism until that is done. It is necessary, however, to forestall one philosophical objection which, if sound, would seem to invalidate beforehand the mode of investigation adopted.

There is a familiar view to the effect that science does not give facts, but artifacts ("fictions" is too strong a word). The rigid bodies, uniform atoms, symmetrical waves, of the text-books, are said not to exist, and accelerations, as well as other functions, to be only numbers. Accordingly, we can not study *actual* causation, for it is not actual but ideal. And being ideal, its nature can be understood only from the abstract, ideal side, as part of a great ideal of rationality, or in Professor Royce's words, as theory of order. Now this objection is really irrelevant. Even if the concepts used by science are not names of existing facts, they are nevertheless, as science studies more deeply, ever closer approximations to existing facts, and their detailed content depends more and more upon the nature of those facts. Indeed, as Professor Royce shows,² the very result of the abstractness of the scientific concepts is that many consequences can be deduced from them, and experimental verification, therefore, may become more manifold. As it were, they draw away from fact in order to get closer and closer to it; so that the full nature of the abstract is realized only in its approximate verification in the concrete. Oddly enough, he does not draw what seems the natural conclusion, that the abstract concept has little meaning by itself, but says, rather, "The order-systems . . . are therefore to be studied with a true understanding only when one considers them in abstraction from the 'probable' and 'approximate' exemplifications which they get in the physical world" (pp. 94-95). Now the definition of causation obtained from these approximately realized concepts is, in general, different from that derived from a simple abstract treatment like that of the theory of order, and is surely much nearer to the concrete. We should gain the truest comprehension of causation by learning its meaning in as close juxtaposition to facts as science can afford us.

² *Encyclopædia of Philos.*, Vol. I., pages 94-95.

This procedure, if still somewhat ideal, is not unmixedly so, but swayed to a large extent by the nature of facts. We shall in the course of our analysis find some reason for suspecting this whole philosophical objection of unsoundness, but it is not now necessary to raise that question. It is not because the abstract views rest upon a mistaken view of science, but because they are so poor and meager of content, that they are considered unprofitable. They do not study the concept of causation as it has been fully developed in its employment with facts.

This same objection sometimes takes another form. Science has obviously two ideals: that of pure rational system, and that of information about particular facts in time and space. One who values the abstract higher than the concrete will probably tend to identify science with the former ideal rather than with the latter or with both. So, *e. g.*, we find one who approaches philosophic questions from the mathematical field, regarding the most perfect sciences as the most mathematical, and the least concerned with events as causes. "In the motions of mutually gravitating bodies, there is nothing that can be called a cause, and nothing that can be called an effect; there is merely a formula."³ "This statement holds throughout physics, and not only in the special case of gravitation."⁴ "... in advanced sciences such as gravitational astronomy, the word 'cause' never occurs" (p. 1). These statements seem very one-sided. They altogether overlook the concreteness of science. If the word "cause" is seldom used in text-books of physics, it is that it is so obviously taken for granted. But it is *sometimes* used. Watson says⁵ "an experiment is simply the artificial arrangement of certain causes, so that . . ."; although, having stated this at the outset, he does not find it necessary to repeat the word "cause" very often in describing particular experiments. Nevertheless, more or less equivalent words, such as "produce," "generate," "give rise to," are frequently used. Science doubtless aims at mathematical system, but it never loses touch with experiment, or with the verification of its deductions, approximately, in particular cases.

There is a more practical objection to this undertaking of ours, which consists in the fact that science changes. Light was once described in terms of the emission theory, then of the ether-undulation-theory, now of the electromagnetic theory. Perhaps fifty years hence the present views on the motion of electrons will be antiquated. Better stick to the formal deductive side alone, and run no risk of refutation by future science! That *would* be the safer course, no

³ B. Russell, *Proc. Arist. Soc.*, 1912-13, page 14.

⁴ *Ibid.*

⁵ "Text-book of Physics," page 3.

doubt. But it would tell us very little about real causation. Meanwhile, the changes of science are not wholly destructive. Statics has grown, practically by addition alone, and Newton's laws remain empirically valid within the margin of error. But even if so extreme a position as that of H. Poincaré were correct, and causal explanations were matters of choice, it would still be our duty to examine the structure of all those which one might choose. At any rate, there is no higher source of knowledge about the causation of the actual world than the latest results of science. In the attempt to reach results so certain that they can never be refuted, we are likely to commit the fault of which the absolutists are accused—I do not say with justice—of getting something which has no possible bearing upon the particulars of experience. While this might be permitted to an Absolute, it is clearly ruled out for a scientific category; for science directs itself toward the existent.

It has been said above that the empirical method is the only one fitted to define the causation philosophy is interested in. That does not imply that it may not involve, in the working out of its analyses, deductive methods. What is needed to-day is a protest against the exclusive use of the latter; a use which by its abstract and exact mathematical form has apparently attained certainty at the cost of truth. We can not, of course, get universals from *mere* summation of particulars, nor the universality inherent in a causal process merely from a number, however large, of specific instances. But we must know the nature of those instances before we can see how the universality of law is able to embody itself. Our method then is alleged to be the only one which makes it possible to understand how the universal is adapted to the particulars.

Now what within the field of the sciences shall we select as cases of cause and effect, and what reject? For not all scientific reasoning concerns these categories. The equations of dynamics are worked out by means of mathematical properties; *that* part of dynamics is clearly not pertinent. The test must be this: wherever a law is spoken of, or a principle, in accordance with which one actual fact, situation, or event uniquely determines another fact—or its own future state—then we have what science treats as causation. The two categories, causation and law, are one in denotation. We must then—without denying that some causes *might* act individually and not by law—govern our selection for the present investigation by the criterion of law.

Perhaps some apology is needed from the present writer for venturing into the field of science, inasmuch as it is only too obvious that he is far from possessing competence therein. This, however, is one of the risks that can not well be avoided. Philosophers who have

had the advantage of scientific training have not been disposed to connect the categories with their empirical manifestations. The form and the matter of knowledge have remained apart, sundered, neither adapted to the other. Some one must attempt to overcome this estrangement. It is very probable that first endeavors in this direction will at least partially fail, owing to misapprehension in regard to the accepted truths of science. But it seems to the writer better to make a move, however inadequate, in the right direction, than to go on waiting in the vain hope that a well-qualified investigator will do it. Mistakes may be corrected, and it is hoped will be. But until some such inquiry into the structure of the concrete world of experience has been made, philosophers will have little to occupy themselves with but an epistemology which is constituted by mutual refutations.

The sciences which aim to deal with facts comprise physics, chemistry, astronomy, geology, biology, history, linguistics, economics, political and social sciences, and the psychological and anthropological sciences. There does not seem to be any systematic body of knowledge which can not be brought under one or more of these heads. Statistics is here excluded, for two reasons: (1) as set forth in text-books like those of Bowley and Yule it is a method of getting as exact knowledge as possible about facts rather than of *directly* finding causal connections, (2) it is concerned, so far as it gives laws, mainly with the important (and by philosophers hitherto largely neglected) concept of probability rather than that of causality.

How many, then, of these sciences offer distinct types of causation? Some of them certainly do not. Thus, geology and astronomy clearly explain their facts by appealing to the laws and causes set forth in physics and chemistry. Biology, for many biologists, does the same. Other biologists claim a special, unique kind of causation, *viz.*, that of an "entelechy." The point is not yet settled; but until all biologists are agreed that there is a kind of causal explanation not reducible to terms of physics or chemistry, we can hardly take it as a datum for our investigation. Though not denying its existence, we may fairly say that until it is generally accepted in biology as a fact, and shown analogous in structure to cases admittedly causal in other sciences, it does not deserve the name causation. The psychological sciences contain a similar uncertainty. Some psychologists—*e. g.*, Wundt—believe in psychical causality *sui generis*; others do not. Until the matter is decided we can not take the alleged cases of psychical causation as data for analysis. In economics, history, political and social sciences, no one, so far as I know, pretends that there is any kind of process not explainable in psychological, biological, physical, or chemical terms; except in the case of history, where we

have the familiar view of Rickert *et al.* This view is by no means generally accepted by historians. Alleged cases of "*individuelle Kausalität*" or historical, personal causation can not then be taken as data. Linguistics, finally, explains by appeal to biological and psychological processes; these we have already dealt with. The only sciences, then, in which by the general agreement of those pursuing them there seem to be independent types of causation, are physics and chemistry. These sciences have analyzed particular causal processes to an extent unparalleled by the others. By this work they have established a claim to primacy; what we shall find causation to mean in *their* fields is what the term should be taken as meaning. Only if Drieschian "*entelechies*," psychical causation, and other unknown types, can be reduced to essentially the same logical structure as that of physical or chemical causation, should they be called by the same name. This is, in a sense, only a verbal issue, but it is one of some importance in the interest of an exact philosophical vocabulary.

So far, we have physics and chemistry on our hands; as wide a field as one could wish. It can, however, be narrowed. The causal processes studied in chemistry are, it appears, regarded by that science as further reducible, and statable ultimately in the terms of physics. Hence arose the science of Physical or Theoretical Chemistry. Professor Nernst, writing twenty years ago, when relatively very little of this reduction had been done, said: "The question of the nature of the forces which come into play in the chemical union or decomposition of substances, was agitated long before a scientific chemistry existed. As long ago as the time of the Grecian philosophers, the "love and hate" of the atoms were spoken of as the causes of the changes of matter; and regarding our knowledge of the nature of chemical forces, not much further advance has been made even at the present time."⁶ "It can not be emphasized enough that we are as yet very far from reaching the goal: *viz.*, the explanation of chemical decompositions by the play of well-defined and well-investigated physical forces" (p. 354). Since then, however, considerably more has been done toward reaching this goal, by the electrical theory of matter.⁷ For the rest, we can hardly take it as containing definite types of causal process, when it is believed to be further reducible. The situation seems to be analogous to that of biology, where types *peculiar to that science* are not generally agreed to exist. In the still somewhat unsettled condition of chemistry on this point, we must leave it and confine ourselves to physics.

In the field of physics there are apparently many kinds of causal connection. Thus: an inelastic body strikes another inelastic body;

⁶ W. Nernst, "Theoretical Chemistry," Eng. tr., London, 1895, page 353.

⁷ Cf. J. J. Thomson, "Electricity and Matter," London, 1904, Ch. 5.

this cause is followed by the effect that both move on in contact. Again, a ray of light enters a glass prism; it is refracted. These are, on the surface, quite different types of causation. An exhaustive enumeration of all such types would carry us through a large text-book of physics. Nevertheless, an account of the cause-effect relation which omitted any of them would be lacking in generality and therefore inadequate. Fortunately, however, the number may be greatly reduced. While the fields of dynamics, heat, light, etc., are at first appearance so disparate, yet physics treats large portions of some fields as cases of some other field. *E.g.*, many types of causal relation in the field of light are reduced to electrical types. In fact, glancing over a standard text-book, we find that there are only a few types that look really distinct. Our task is now to show these forth.

The total field of nature, so far as studied by physics, is comprised under the following divisions: mechanics (including statics and dynamics), "properties of matter" such as elasticity, capillarity, density, etc., heat, sound, light and radiant energy, magnetism, electricity. To causal connections in each of these fields we must add those embodied in transformations of energy from one field to another; *e. g.*, of electricity into light, of motion into heat or light, etc. This classification is not quite a mutually exclusive one, nor has it any obvious *fundamentum divisionis*, but it contains all that is known, with general agreement and certainty, of the actual causal relations in the world. Let us take them in order, beginning with mechanics.

The inclusion of statics, or the study of the causes of equilibrium, encounters a certain objection. Some philosophers would say that here are no *events* and therefore no causal connection. Several answers to this are possible. (1) It rests on a preconceived definition of cause, and can in this inquiry have no weight. Statics *explains why* a body is in equilibrium: it regards the position of the weight-arm as due to that of the power-arm of the lever. In other words, this field is to be included because science treats it as if included. (2) A condition of equilibrium may be regarded as an event, as much as a motion. It occupies time and exists in the world of fact. (3) There is no *a priori* reason why rest can not be a cause of, as well as caused by, either rest or motion. Continuation of the same condition in time is as real, and as dependent on preceding conditions, as change. It may be that things as inert as circles do the causing in some cases. It is a wholly empirical question.

What are the elementary causal situations in statics, out of which *all* the situations studied in that science are composed? These will be the types sought for. They are, I think, just three in number.

They are the two laws which are respectively called (1) the principle of the transmissibility of force, (2) the principle of composition and resolution of forces, and (3) the definition of the moment of a force about an axis, as producing a tendency to rotation. Every statical situation seems to be a case of one or more of these. Thus, the lever is a case of (3), the centre of gravity of a body is determined by (2) and (1), the pulley is a case of (3), the inclined plane of (2). The statics of fluids (liquids and gases) contain no principles beyond those of the statics of solids. Even if it should be the case that these three elementary cases are further reducible, it will do little harm; the danger is that we examine too little rather than too much.

Dynamics is in general parallel to statics, their difference depending upon that between *tendency* to motion and *actual* motion. Indeed, "every dynamical problem can, by the help of D'Alembert's principle, be reduced to one in Statics."⁸ We might, then, simply consider the three laws of Newton as the elementary cases for both Dynamics and Statics, and let that suffice. "The principles of Newton suffice by themselves, without the introduction of any new laws, to explore thoroughly every mechanical phenomenon practically occurring, whether it belongs to Statics or to Dynamics."⁹ Nevertheless, it is sometimes more conducive to clear insight to show different instances of the same type. We shall therefore consider the composition and resolution of velocities and accelerations, the law of inertia and uniform motion, the case of a body's motion as changed by the external force of gravitation (the second law), and of bodies undergoing impact with other bodies (the third law). In regard to Newton's first law, it is true that it does not hold for very high velocities, because for such velocities the electrical state of the particle changes and increases the mass. This, however, is no denial of the law. It also happens that the bodies which act in accord with the causal laws of dynamics, act at the same time under certain statical conditions; so that the static and dynamic types are at once combined in single events. This combination of many causes or effects into one must also be dealt with.

Further cases under Mechanics are such as show transformation from a static to a dynamic situation or the reverse. For example, a pressure is the cause of a motion; the attraction of the earth causes a body to fall when the support is removed. In general, this type of case may be called the passage from potential to kinetic energy, or the reverse. It forms, I think, a distinct type of causal sequence and as such deserves special examination.

⁸ Routh, "Elementary Rigid Dynamics," page 316.

⁹ Mach, *Science of Mechanics*, Eng. tr., page 256.

“Properties of matter” include elasticity, friction, resistance of a medium to motion through it, the liquid, viscous, and gaseous states, surface tension, capillarity, diffusion, osmosis, cohesion, density, solution, gravitation, crystallization. The ways in which these properties behave, and determine events, are, of course, types of causal connection. Some, however, have been reduced to mechanical cases: *e. g.*, the liquid and gaseous states are treated under the mechanical sciences of hydrostatics, hydrodynamics, and kinetic theory of gases. Surface tension, capillarity, diffusion, osmosis, and solution are also conceived in mechanical terms, *i. e.*, terms of molecular action. Viscosity is a property of liquids which is due to internal friction. There remain, then, elasticity, friction, resistance, density, cohesion, gravitation, and crystallization. None of these has as yet been wholly reduced to cases of mechanical action, static or dynamic. In this division, also, it will be best to place that very general property of matter which is defined under the law of indestructibility, or, as sometimes named, the conservation of mass.

The field of events classified under Sound contains none but mechanical types, combined with the above “properties.” Under Heat are two kinds: (1) those events, such as convection, conduction, expansion, etc., which are either clearly mechanical or are explained by the dynamical molecular theory of heat, and (2) radiant heat. This last has been placed under the head of Radiant Energy, which in turn is reduced to terms of electrical disturbance. All the phenomena of Light are accounted for in terms of electricity. Of the other known kinds of radiant energy, such as X-rays, Becquerel rays, etc., so far as they are explained the same is true. The field of Magnetism contains only such events as are reduced to cases of electrodynamics. Under Electricity the fundamental kind of event seems to be the mutual attraction and repulsion of small charged bodies. This may perhaps be couched in terms of ether-strain, but is in any case at present conceived to be a non-mechanical type. The development of this conception in the electron-theory has in fact explained so many phenomena of chemistry that it is regarded by many as indicating the ultimate constitution of matter. However that may be, we do seem to find in the fields of Heat, Light, Radiant Energy, Magnetism, Electricity, and Chemical Transformation, a great class of events of a unique type. Each such event constitutes a cause-effect sequence as clearly as does mechanical impact or gravitation; but neither seems as yet reduced to the other. According to the present view of science, then, all cause-effect situations in nature are in the last analysis, and so far as there is general agreement, either mechanical cases, or cases determined by “properties

of matter," such as elasticity, friction, etc., or cases of electricity, or combinations of some or all of these. And this can now be seen to hold as well for transformations of energy from one kind to another, viz., heat to motion, electricity to heat or motion, heat to light, etc. For the electric "current" is conceived, as we shall find, to be motion, and hence may lead to motion in the shape of light, heat, or mechanical energy; and conversely. In general, no new type of causation appears in such processes; so we may omit the study of transformations of energy. Our task is now to ascertain the logical structure of the typical events in each of these three fields: that of Mechanics, of "Properties of Matter," and of Electricity.

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RULE VERSUS DISCRETION

WHEN the conference on Legal and Social Philosophy decided to place as the central problem for the next meeting the question of the Province of Rule and Discretion in the Administration of Justice, one of our honored colleagues, who had followed the first meeting with generous sympathy, expressed grave doubt as to whether the question was of sufficient general or philosophic importance. The prevailing absorption of philosophy in the problems of epistemology makes it probable that this doubt is shared by a great many, and makes it incumbent on us to show cause why philosophers should busy themselves with this question. It will, however, be sufficient for the present purpose if the following considerations succeed in indicating genuine philosophic problems rather than any adequate solution.

I

Amidst the diverse attitudes which people take to our courts of law, nothing is more usual than the remark of educated people: "If our judges would only occasionally forget their legal technicalities and rely more often on common sense and justice, we would have less reason to be dissatisfied with their work." This remark is based on the belief that the end of courts of law is to render justice, and that the technical rules are at best only means towards this end and ought not, therefore, ever to stand in the way of the end itself. To which the lawyer answers, that if the judge is to feel free to disregard a law in the interest of what he thinks justice, then the law becomes a dead letter and we are given over to the arbitrary sway of caprice, which is equivalent to anarchy or tyranny. The classical expression of this point of view occurs in Maine's *Ancient Law*. Commenting on the